Engaging High School Girls in Native American Culturally Responsive STEAM Enrichment Activities

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Abstract

Providing science, technology, engineering, art, and mathematics (STEAM) culturally responsive enrichment activities is one way of promoting more interest in science, technology, engineering, and mathematics (STEM) studies and careers among indigenous students. The purpose of the study was to explore the impact, if any, of STEAM culturally responsive activities, embedded with Dakota/Lakota values and traditions, in a partnership between a mainstream college of engineering and a population of high school girls at a Federal Native American boarding high school. We engaged in a quantitative and qualitative, exploratory place-based case study in a technical action partnership with a small group of participants/respondents. This study was rooted in the situational perspective of Critical Theory, Liberation Theology, Social and Cultural Capital Theory, and Native voice from the position of discovery. In a Likert scaled post-project survey, the majority of respondents reported that they agreed or somewhat agreed that they liked to study science, technology, and engineering (STE), and that they could make a real difference in their home community if they majored in those studies in college and earned a degree. They reported less enthusiasm for mathematics. Respondents reported changes, if any, in their opinions about STEM after being part of STEAM Girls enrichment activities as follows: a majority indicated positive or improved attitudes, and no one reported increased negative feelings. Results of a post-project focus group indicated a link between culturally relevant enrichment activities and increasing interest in STEM studies and STE careers in this situation at this place. Results indicate that women role models may improve interest in STEM, and that indigenous relevancy of activities matters, even if not tribally specific.

Keywords: female, pre-college, motivation, case study

Introduction

Native Americans are severely under-represented in STEM fields (National Academies of Sciences, Engineering, and Medicine, 2016), and there is increasing interest in improving diversity. To explore under-representation of Native American girls in STEM fields, the South Dakota Space Grant Consortium (SDSGC) and the National Science Foundation's (NSF's) Pre-engineering Education Collaborative (PEEC), partially funded a program that partnered Flandreau Indian School (FIS) with South Dakota State University's (SDSU's) Civil and Environmental Engineering Department. The program was called STEAM (science, technology, engineering, art, and mathematics) Girls.

The purpose of the project was to explore the degree, if any, to which certain culturally relevant experiential learning activities combining traditional Native arts and crafts with STEM, may potentially increase interest in STEM studies and careers among high school girls at FIS. Through this exploratory case study, we gathered and reported student responses after engaging with participants in those enrichment activities. There was no intent to teach standards or theoretical concepts within STEM fields. The goal of the activities was to deepen STEM interest and to demonstrate relevance to the participants' daily lives and community well-being, in the hope that some of the girls would consider STEM majors and careers in the future. Research by Kant and others (2015a) indicated that first there must be interest in STEM fields. There must also be community relevancy, or most Native American students of prime college age in South Dakota would not select STEM majors. Currently, for example, engineering is viewed by many Native Americans of typical college age, as a privileged pursuit and not as a caring profession such as nursing or counselling (Kant, et al., 2015a).

Background

The current project was originated by some Pre-engineering Education Collaborative (PEEC) leaders in South Dakota who often found it difficult to recruit Native American students. Some of those PEEC leaders turned to their previously referenced research into why more Native Americans do not become engineers (Kant, et al., 2015a). The PEEC research pointed the way to trying more cultural relevancy to create interest. This exploratory case study includes in-depth methodological and theoretical underpinnings, as well as a review of literature that influenced project design. We provide a description of the program, as well as results from post-surveys and a post-focus group, conducted after FIS participants engaged in culturally-responsive STEAM enrichment activities led by the research team. The study sample was small, and it was not possible to work with the same individual students from the beginning to the end of the study, although a core group persisted. Thus, results should be viewed with caution.

Review of Literature

Basis for Culturally Relevant Enrichment Activities within the Methodology for This Population of Girls

Recent research by Microsoft Philanthropies (2017), including over 11,000 participants across Europe, indicated that girls and young women become interested in STEM at ages 11-12 and rapidly lose interest at ages 14-15. They recommend women role models and hands-on activities relevant to girls' lives, among other remedies.

To generally increase student success, the tribal college movement has long espoused building renewed respect for Native American culture and pride in traditional Native values through culturally responsive teaching and learning according to Boyer (2016). Caution is necessary, however, in applying a one-size-fits-all mentality to culturally responsive teaching and learning for any group of persons outside the majority culture. For example, sometimes American Indian/Alaska Natives (AIANs) are simply included with "minorities" or "under-represented" groups when categorizing people of color in some research studies, since Native American numbers are often very small in many research samples. Thus, AIAN populations are sometimes inappropriately included when reaching conclusions about under-represented groups. To further complicate the situation, there are hundreds of tribes, and each is unique. Overgeneralizing and stereotyping may result (Morgan, 2009). With those cautions firmly in mind, we offer the following.

Native Americans often hold cultural traditions as lifeways that can be powerful motivators for their students when combined with other aspects of culturally responsive teaching and learning. Cultural identity is often embedded in their indigenous ways of life and learning (Kant, et al., 2015b). For example, Oglala Lakota College (OLC), a tribal college on the Pine Ridge Reservation in

South Dakota, includes the following as part of their Vision Statement for their Math, Science and Technology (MST) Department: "To provide constructivist-learning activities in science, technology, pre-engineering, and mathematics while incorporating traditional Lakota values."

Pewewardy and Hammer (2003) and Morgan (2009) generally have recommended culturally responsive teaching and learning practices for many Native American students. Ladson-Billings (1995, p. 483), from the perspective of Black feminism, has encouraged teachers to "systematically include student culture in the classroom as authorized or official knowledge," specifically including Blacks, Hispanics, and Native Americans.

Astronaut J. B. Herrington (2014), a Native American, lamented in his Ph.D. dissertation, a NASA-themed project among Native American students on the Duck Valley Reservation, that in hindsight he recommends including cultural relevancy. Herrington specifically recommended invoking the perspectives of anthropologist Jack Weatherford (1988) in providing cultural relevancy in projects for Native American students. Weatherford (2010) is known for books such as *Native Roots: How the Indians Enriched America*. Herrington offered the following advice for future programs.

> *Present historically relevant examples of Native Americans as natural scientists and engineers. Each student in this study commented that they were not exposed to culturally relevant examples of Native Americans and how their ancestors developed and demonstrated scientific and engineering concepts without the use of Western science or technology.* (Herrington, 2014, pp. 158-159)

Activities with messaging that promotes STEM careers, while involving caring for communities and improving quality of life, tend to attract many Native Americans regardless of gender (Kant, et al., 2015a; Smith, et al., 2014), and such activities tend to attract females more than males in the general population (Colvin, et al., 2013). In working with Native American students in South Dakota, researchers have consistently reported increased interest in STEM studies among Native American students when lessons and projects include Native American traditions, cultural values, or role models (Kant, et al., 2014ab; Sawyer, et al., 2014; Tinant, et al., 2014; Davis, et al., 2016; Lagarry, 2016; Parisky, et al., 2016).

The following are examples of some of the PEEC program's culturally responsive Native American teaching and learning activities in STEM in South Dakota and North Dakota. In South Dakota, Oglala Lakota College (OLC) instructor Hannan Lagarry (2016, pp. 48-50) reported that he employs hands-on experiential learning pedagogy in the Math, Science, and Technology Department (that includes pre-engineering). Lagarry reported that his teaching is place-based, student-directed, and centered on improving the quality of life and cultural preservation for persons living on the Pine Ridge Reservation governed by the Oglala Lakota Sioux Tribe.

In reflecting on PEEC's efforts to bring engineering to Native Americans and Native Hawaiians, Parisky and others (2016) concluded that,

> *[c]reating and implementing projects with indigenous roots helps to increase interest in STEM and generates cultural pride that may improve student persistence, and it helps in recruitment. PEEC projects rooted in indigeneity increase encouragement from the community, family, and Elders, who help to keep PEEC students moving forward to reach their goals.* (Parisky, et al., 2016, p. 63)

At tribal colleges in North Dakota, Davis and others (2016, pp. 37-38) reported increased PEEC student persistence and interest in STEM studies through invoking cultural relevancy. They paired lessons prepared by Native American cultural/spiritual teachers with STEM instructional units taught by tribal high school teachers and North Dakota State University faculty, the latter mostly engineers.

While racially based content is often included in PEEC activities, others report that such content is not a necessity in their programs. For example, Hammond (2015) found that culturally responsive teaching and learning does not *have to* [emphasis, Hammond's] involve "racial background" in lesson content, although such teaching often does. In explaining her position, Hammond noted the following.

> *One of the biggest misconceptions about culturally responsive teaching is thinking you have to tie the lesson's content to African American or Latino students' racial background. The common belief is if you mention Africa, Mexico, or famous black and brown high achievers, it will spark students' attention. Then they will be motivated to participate.*
>
> *In reality, culturally responsive teaching is less about using racial pride as a motivator and more about mimicking students' cultural learning styles and tools. These are the strategies their moms, dads, grandmas, and other community folks use to teach them life skills and basic concepts long before they come to school and during out-of-school time.* (Hammond, 2015, n. p.)

Hammond recommended making lessons more culturally responsive as follows: "Gamify it." "Make it social." "Storify it" (2015, n. p.).

Lareau (2011), a sociologist, offered a different perspective on culturally responsive teaching and learning, based on parents' child rearing practices. She reported that a child's life chances and likelihood for school success are increased by parental child rearing practices that are rooted in, and responsive to, the cultural values of the American middle class. Quite simply, the American education system is deeply culturally biased in favor of the middle class.

Lareau contrasts the "cultural logic" (2011, p. 237) of two systems of child rearing based on social class with less emphasis on race in predicting who succeeds in school, who gains diplomas, and who does not. One constitutes the intensely adult-organized and sometimes exhausting child rearing practices of middle class culture that she labeled "concerted cultivation." The other system, more hands-off, characterized by the poor and working classes' culture, she labeled "natural growth" (Lareau, 2011, pp. 1-2). Lareau's research results overwhelmingly predicted that the children of parents who practiced concerted cultivation achieved more success in school than children raised by parents who practiced natural growth. When she conducted a follow-up study with the same families, ten years later, results were generally the same.

Research by Lareau helps to explain the commonalities, based on social class, among professionals, regardless of racial identity. Thus, her findings have important implications in working with many Native American students since a highly disproportionate share are from families in poverty. Holding a college degree often creates upward social class mobility and increased income for such a family, as well as impacting the parent's child rearing practices in the direction of middle class values. College degree holders often possess important "social capital and cultural capital," terms by which Bourdieu (1984, p. 114; 1986) generally meant the total social linkages and cultural preferences accumulated during an individual's upbringing that provide him or her with access to even more social and cultural capital, while increasing potential for more "economic capital," (i.e., wealth) (Bourdieu, 1986).

As an applied example of the theories of Bourdieu and research by Lareau, the following is the experience of a Native American college student, James Sanovia, seeking more "social, cultural, and economic capital" in order to negotiate graduate school in engineering. Sanovia was raised in an environment characteristic of a financially disadvantaged class rather than middle class childrearing practices. He is a PEEC Co-Principal Investigator and faculty member at OLC on Pine Ridge Reservation. Sanovia (2016) reflected about his experiences as a college student at a tribal college, OLC, compared to South Dakota School of Mines and Technology (SDSMT) where he was enrolled in undergraduate and graduate engineering programs in Rapid City in a non-reservation setting. He noted that he and his Native American classmates at SDSMT were curious about how the system worked, since

> *. . . most Native American students are first generation college students, and they did not grow up in an environment where such topics [engineering programs] were discussed or even mentioned.* (Sanovia, 2016, p. 72)

Out of curiosity, Sanovia (2016, pp. 72-73) asked non-Native SDSMT students some of the following questions. "When do you study and for how long? What does your homework look like? Do you study with others? Do you do homework with others? Do you study on weekends?"

1. October 28, 2015; 1-5 pm
Project leaders collected completed pre-surveys. They explained the purpose of the STEAM Girl program: Do certain activities increase interest in STEM studies and careers? They noted that the activities would be relevant to indigenous cultures, particularly Lakota/Dakota. They explained that the first STEM practitioners in this hemisphere were Native Americans who operated through trial and error and through centuries of intimate knowledge of their ecosystems. At FIS, project leaders introduced the newly proposed herbarium and its purpose, along with its metal cabinet and supplies. The group made plant vouchers from local Native plants that project leaders had collected in summer and fall when the plants were in bloom or had set fruit. The group made fry bread and served it with wild plum jelly. They explored and identified Native trees and shrubs on the periphery of the heavily wooded FIS campus that includes adjacent wetlands, where they encountered a dozen wild turkeys.

2. November 18, 2015; 1-5 pm
At FIS, the group continued to develop the school's herbarium, cooked bison and Giant Canada Goose including chokecherry sauce, cooked *wasna* (Native fruit pudding), and served traditional foods with Native plant fruits (plums, rosehips, wild grapes, and elderberries). They planted wild rose roots and seeds from wild plums, elderberries, rosehips, and wild grapes. The group collected milkweeds and cattails on the FIS campus and painted dried milkweed stems and pods to make bouquets. They released wind-born seeds from existing cattails at FIS. They assembled traditional Dakota/Lakota recipes using Native fruits and other plant parts. Project leaders began assembling an activities booklet to be distributed at project's end.

3. December 2, 2015; 1-5 pm
The group took a bus trip to SDSU. The first campus event was a traditional meal of bison, fry bread, and Native plant jellies, and *wasna* (plum pudding) at the American Indian Student Center. Volunteers who helped to prepare food held B.S. and/or M.S. degrees and were the mother and grandmother of two of the project's college student assistants. Several Native American students from SDSU attended the meal and each talked about his or her life experiences on campus and answered questions from the STEAM Girls. The group visited the Agricultural Heritage Museum where the Taylor Herbarium curator explained the purpose and importance of herbaria and why Native plant study is important. The group toured the Taylor Herbarium with the curator who emphasized Native plants and their vouchers. Finally, the group toured the SD Art Museum, where guides emphasized a Native American Art exhibit.

4. December 9, 2015; 1-5 pm
At FIS, project leaders showed a rare green turtle PowerPoint illustrating a project at Oglala Lakota College (OLC), Pine Ridge Reservation, and they explained how OLC students and faculty are working to conserve turtle habitat through electronic tracking. The group examined common box turtle shells and made them available to the girls to make traditional dance rattles. They discussed the upcoming visit to EROS that would feature ground cover imagery from space. Project leaders presented a history of the glass trade bead and beaded floral versus geometric designs among the Dakota/Lakota. Project leaders explained how beadwork designs could be created in a spreadsheet (Fig. 1). They distributed beadwork patterns and individual kits, and participants began traditional Lakota/Dakota arts and craft projects.

5. January 27, 2016; 1-5 pm
The group took a second bus trip to SDSU. On the SDSU campus, an engineering professor provided a hands-on lesson comparing some properties of liquid glass and bead manufacturing to sugar syrup in candy making. The group toured the Dykhouse J. Dykhouse Stadium and score board, emphasizing that Daktronics founders were professors from SDSU's College of Engineering. The group again toured the Agricultural Heritage Museum where some of the STEAM Girls had asked to spend more time, since their earlier visit was brief.

6. February 17, 2016; 1-5 pm
The group took a third bus trip to SDSU led by the project's Native American women student assistants. The College of Nursing provided a welcoming meal during the tour and activities. The Davis Dairy Plant served ice cream while the group toured their manufacturing facility.

Table 1. Summaries of STEAM Girls Meetings and Enrichment Experiences.

7. February 24, 2016; 1-5 pm
At FIS, the group continued working on beadwork and porcupine quillwork arts and crafts projects. Project leaders presented a short PowerPoint, "Road Ditch Flowers from Pine Ridge Reservation," providing common names for each plant. The STEAM Girls selected the species of trees, bushes, and other Native plants that the group later ordered from the Brookings County Conservation District to refurbish the FIS landscape on Earth Day in April and to provide a resource for the new herbarium at FIS.

8. March 9, 2016; 1-5 pm
The group took a bus trip to EROS, with guides emphasizing ground cover plant imagery from space. The EROS guides explained what types of college degrees are necessary to work there. Project leaders distributed booklets and posters about regional plant identification so that each STEAM Girl owned personal guides in order to continue to learn field identification of plants.

9 March 30, 2016; 1-5 pm
At FIS, the group completed arts and crafts beadwork/quillwork projects. The group produced more plant vouchers and assessed what was already in the FIS herbarium and how to continue in the future. Project leaders posted information at FIS to promote the Earth Day planting event as a way of inviting more FIS students, staff, and volunteers to help.

10. April 22, 2016; 1-5 pm
At FIS, the group conducted an Earth Day event planting Native shrubs, trees, and other plants. The group planted 100 Native plants alongside an existing shelterbelt on the FIS campus to refurbish this selected area to serve the herbarium in the future (Figure 1). The group shared fry bread and Native plant jelly. Some of the STEAM Girls completed post-surveys and participated in a post-focus group.

Table 1. (Cont.) Summaries of STEAM Girls Meetings and Enrichment Experiences.

Sanovia (2016) noted that in order for persons outside the middle class to gain advantage in a middle-class based system, they need to know the rules, whether it is non-reservation culture, campus culture, academia culture, science culture, technology culture, engineering culture, or mathematics culture, and an endless list of other macro- and micro-cultures.

In the pilot study conducted by Kant and others (2015a), designed to determine why more Native Americans do not take up engineering in South Dakota, a Native American participant remarked that he and others needed to know more about how the system works if he were ever to select engineering studies. The participant advised as follows.

> *Give students more information about it and about the opportunities. I would get graduates, who have a job in engineering to come in and express their experiences, whether they are native or non-native. . . . Students could get every little detail from dorm life to academics, summers, and how to pay for it. Let students know that there are different ways to accomplish those things, but how they persevered, without race being a part of it.* (Kant, et al., 2015a, p. 27)

STEAM Girls Enrichment Activities

The project that is the focus of this paper was known as STEAM Girls after the movement that advocates combining STEM plus art (Maeda, 2013; Bequette and Bequette, 2012). The "STEAM Girls" hereafter refers to FIS high school participants. "Project leaders" refers to the PI and Co-PI's, along with their assistants who included five Native American women students from SDSU (sometimes including selected relatives as volunteers). "The group" refers to participating STEAM Girls and project leaders.

Two of the professional project leaders with the most time to devote to enrichment activities hold Ph.D.'s in biological sciences or engineering and have unique expertise in Dakota/Lakota arts and crafts, and cultural traditions. A third professional project leader holds a Ph.D. in anthropology and is an enrolled tribal member in South Dakota with life-long experience in Native American culture in the state.

Project leaders emphasized Dakota/Lakota traditional arts and crafts, mostly focused on crafts. Leaders also included bus trips to selected educational sites to help the STEAM Girls to build social and cultural capital in their life experiences through enrichment activities. Those bus trip activities are examples of the "concerted cultivation" practiced by middle class parents in Lareau's findings.

The group met monthly (Table 1) from noon to 4:00 pm from October 2015 to April 2016 at the FIS Tea Room with kitchen facilities and tables, or at grassy shaded areas on the FIS campus, or during bus trips. The group took a bus trip and tour of the Center for Earth Resources Observation and Science (EROS), a United States Geological Survey (USGS) facility near Baltic, SD; and three bus trips and tours to STEM and arts facilities at SDSU. Those tours included the Jerome J. Lohr College of Engineering, the Taylor Herbarium, the American Indian Student Center, the South Dakota Art Museum, the Agricultural Heritage Museum, the College of Nursing, the Davis Dairy Plant (ice cream manufacturing), and the massive Daktronics scoreboard at the Dana J. Dykhouse Stadium. Flandreau Indian School (FIS) administrators and their science teacher selected dates and meeting times.

The two most dominant themes for activities at the FIS campus included Native plants and glass making because of the central importance of Native fruits and glass beads in traditional Native American life in South Dakota. Another reason was that key project leaders had expertise in those specific topics. The group identified characteristics of traditionally used Native fruits and plants, made and ate tribal foods, collected Native plants, and prepared herbarium-style plant vouchers, established an FIS herbarium, and related the plant activities to NASA's Visible Earth website and plant groundcover from space. The group made wild rose petal perfume. On Earth Day, the group and some FIS employees planted over 100 traditional Native plants on the FIS campus as a resource for their herbarium, with each STEAM Girl tagging a plant with her name to personalize the experience and create a

Figure 1. At the FIS campus, STEAM Girls, along with SDSU project leaders and assistants, and FIS staff installed Native plants that remain important within Dakota/Lakota culture. The plants will provide a resource for the new FIS herbarium, as well as fruit for making traditional foods. Each STEAM Girl tagged a plant with her name as a legacy experience. The most favored plants were chokecherries and plums.

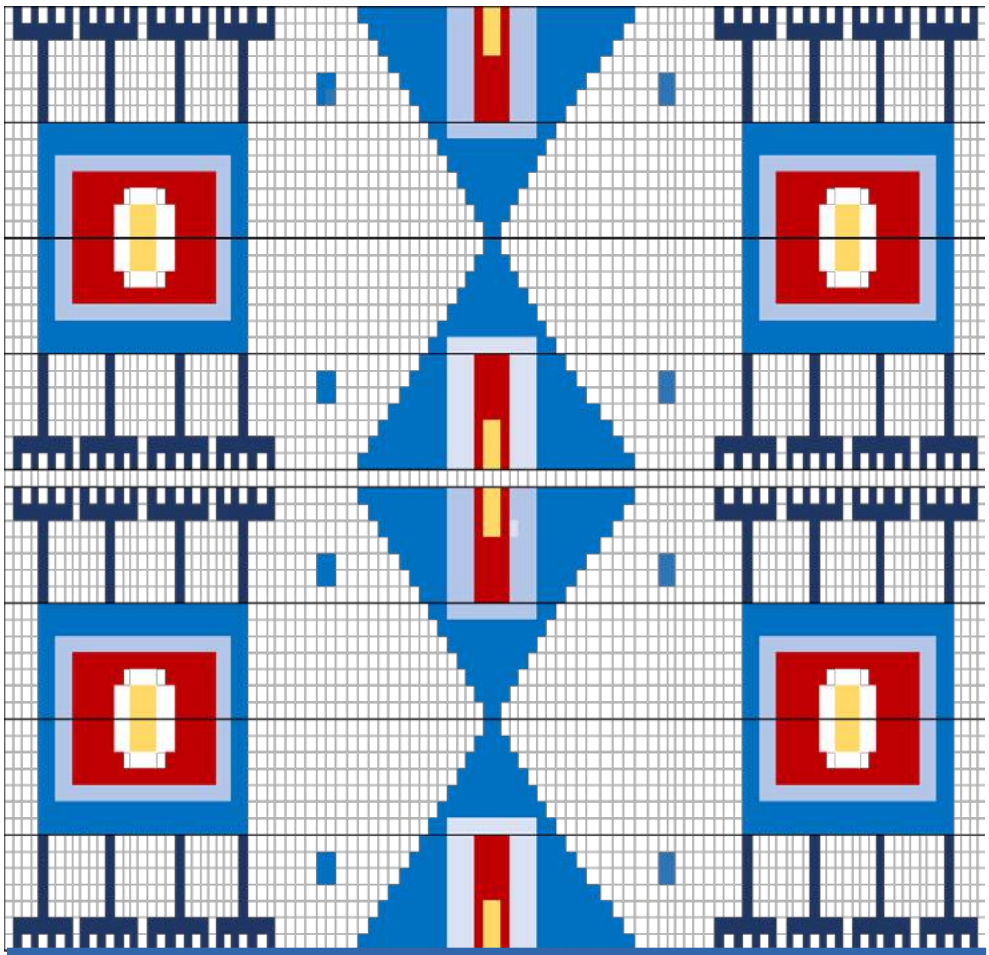

Figure 2. This is a traditional Dakota/Lakota lazy stitch beadwork design created in a spreadsheet by reducing rectangular cells to squares and selecting colors. It is an example of creating interest in learning to use spreadsheets through culturally responsive teaching. Historically, such designs were borrowed from wool Caucasus rugs brought to the area by white settlers in the 1870s and 1880s (Lyford, 1940).

legacy experience (Fig. 1).

Within the glass making theme, the group explored glass manufacturing techniques, considered liquid glass-like properties in sugar-based candy through hands-on work, analyzed glass beads and historic beadwork designs, and introduced a system of laying out beadwork patterns using a spreadsheet (Fig. 2). They made traditional Lakota/Dakota glass beadwork and porcupine quillwork using brain-tanned hides, rawhide, sinew, Giant Canada Goose feathers, ermine pelts, box turtle shells, horse hair, and many other authentic materials (Fig. 3).

Project leaders produced a booklet, available at SDSU's online repository, of some STEAM Girls activities (Kant, et al., 2016b), particularly Dakota/Lakota plant recipes for traditional foods, as well as warnings about cyanogenic glycoside toxicity in some plants. The booklet also includes instructions for assembling a small still for plant based perfume making. As a separate product, project leaders prepared eight pages of patterns and instructions for authentic, traditional Dakota/Lakota beadwork and quillwork and distributed those to the STEAM Girls, some of whom had little prior experience in such activities.

Methodological and Theoretical Orientations

Project leaders selected Dakota/Lakota-related culturally responsive enrichment activities with which they were familiar and had expertise. The project team included SDSU faculty, professional staff, student assistants, and volunteer helpers who mostly mirrored the ethnic diversity of the STEAM Girls school population, a strategy reported as successful in promoting STEM among other non-majority student populations (Kendricks, et al., 2013). The depth and breadth of the activities was increased or decreased based on the ebb and flow of the interest levels of the participating FIS high school girl students and the project's SDSU Native American intern assistants and selected volunteer helper relatives.

The tools or techniques used to gather data included a two-part post-survey and a post-focus group of participants to collect both quantitative and qualitative data. The methodology was case study, as noted, with characteristics of action research (Case and Light, 2011, p. 197; after Cousin 2009, p. 151). The theoretical perspective included aspects of Paulo Friere's (1970 and 1976) critical pedagogy movement and liberation theology, particularly his books *Pedagogy of the Oppressed* and *Education as the Practice of Freedom*. Freire espouses cooperation and unity among oppressed, colonized populations in order to free themselves through education using their own local solutions.

Detractors sometimes refer to studies such as this one as "deficit-based" (Harper, 2010), where researchers are charged with treating participants as though there were something missing from the group studied, and that whatever is missing needs to be added in order for participants to succeed. Deficit-based studies are criticized

Figure 3. This Giant Canada Goose feather hair ornament was made by one of the STEAM Girls. They also produced wing feather dance fans, turtle shell dance rattles, and strike-a-light bags made with brain-tanned deer hides. Handling traditional Native arts and crafts materials increased their STEM connections by creating awareness that Native Americans were the first STEM practitioners in their homelands.

for ignoring or failing to adequately acknowledge the realities of institutional barriers as major impediments to the educational success of under-represented minorities. We acknowledge a primary institutional barrier in this study: that the American education system is based on middle-class values, but changing that system is beyond the scope of this study. Through Native voice, we examine how the oppressed may participate in their own liberation, through self-empowerment and local educational solutions: culturally relevant teaching and learning. There is, indeed, something missing that might be added to increase school success: Freire called it a "pedagogy of the oppressed."

Another theoretical perspective that underpins the research includes Bourdieu's Social and Cultural Capital (1984; 1986). Lareau's (2011) sociological research sheds light on the process by which persons acquire "social capital and cultural capital," preferences and linkages that may increase success in gaining educational credentials, enabling an increase in personal economic capital, and an increase in upward social mobility. Other examples of social class research aimed at improving educational outcomes of under-represented minorities, although not specifically Native Americans, include studies by Ovink and Veazey (2011), and Bodovsky and Farkas (2008).

The relevant situational perspective (seeking to understand a particular situation) is Critical Theory, often inductive and dialectical in reasoning. Critical theory as defined by Case and Light (2011, 189; after Koro-Ljungberg and Douglas, 2008) "is explicitly directed towards critique of social inequities and power relationships with the ultimate goal of facilitating social change." Aspects of critical theory that inform the research include Critical Pedagogy of Place as it relates to place-based and land-based pedagogies where curricula do not often integrate alternative world-views as compared to Westernized views (Gruenewald, 2003; Tuck, et al., 2014). The current study, focused on a small sample of an indigenous populations' views through Native voice as espoused by Meyers and others (2016).

The epistemological (philosophy of knowledge or theory of knowing) basis of the research is *a posteriori* knowledge, gained through experience from a position of discovery and exploration. Thereby, the researchers do not seek statistical generalizability drawn from the data, but rather, the validity of a study may be relevant in the context of research by others or possibly only generalizable within the population under scrutiny (Lincoln and Guba, 1985).

Participants and Respondents

The overall STEAM Girls program served more than 25 FIS students. All of the participants self-reported Native American ancestry, including various tribes from across the United States, with less than a majority from South Dakota tribes. Project leaders were not allowed by FIS administrators to reveal participants' or respondents' names or other identifying information because of privacy restrictions. Such identifying data included tribal affiliations or states of origin. All participation in STEAM Girls activities was voluntary, and there was no penalty for withdrawing from the project.

Data Collection: Parts 1 and 2 Post-Survey, and Post-Focus Group

The STEAM Girls meetings usually included the same core group of about 10 participants in grades 9 through 12. There were from 11 to 25 total participants per meeting with an average attendance of 20 FIS girls at each of the 10 monthly or bimonthly meetings over a 7-month period.

After FIS administrators approved the research instrument documents, project leaders first administered the post-survey. At the final STEAM Girls meeting, 17 participants responded to the post-survey, part 1, statements 1-8; but only 13 of 17 responded to the post-survey, part 2, statements 9-16; and only 7 of 17 responded to the focus group statements. Of the 17 respondents at the final meeting, they reported attending from 2 to 10 meetings.

For the post-survey, part 1, items 1-8, respondents quantitatively ranked statements on a Likert scale from 1 (disagree) to 5 (agree) that focused on their like or dislike of STEM studies and their perceived value or lack of value in their earning STEM degrees that could help their communities. Project leaders included the statement about communities, since research by Smith and others (2014) and by Kant and others (2015a) indicated that a local community connection is of primary importance as a motivator for many Native American students.

Statements for the post-survey, part 1, items 1-8 included the following.

1. I like to study subjects involving science.
2. I think I could make a real difference in my home community if I majored in science in college and earned a degree.
3. I like to study subjects involving technology.
4. I think I could make a real difference in my home community if I majored in technology in college and earned a degree.
5. I like to study subjects involving engineering.
6. I think I could make a real difference in my home community if I majored in engineering in college and earned a degree.
7. I like to study subjects involving mathematics.
8. I think I could make a real difference in my home community if I majored in mathematics in college and earned a degree.

For the post-survey, part 2, items 9-16, respondents qualitatively provided short written responses to open ended statements about each discipline in the acronym, STEM. The following is an example of a statement to prompt a response. "Before being part of STEAM Girls, I used to think this about science. Now I think this about science."

For the semi-structured post-focus group, project leaders led discussions and documented qualitative responses through notetaking with the following questions as prompts in order to elicit oral discussion among respondents.

1. What did you think of the STEAM Girls activities?
2. What activities should we increase?
3. What were your favorite parts of the STEAM activities?

Results: Findings and Analysis

Post-Survey Part 1

For the post-survey part 1 statements 1-8 (Fig. 4), a majority of respondents (n=17) reported that in the cases of STE, they agreed or strongly agreed that they liked to study each of those subjects and that they thought they could make a positive difference in their home communities with a college degree in any of those fields. In contrast, less than a majority reported those attitudes towards mathematics.

Post-Survey Part 2

For the post-survey part 2 statements 9-16, 13 (n=13) of 17 girls responded. Questions were open-

ended beginning with the phrase, "Before being part of STEAM Girls, I used to think; now I think . . ." for the four individual disciplines within STEM. A majority of respondents reported a change in attitude from previously negative or neutral to now more positive for science and engineering (7 of 13, 54 percent) and for technology and mathematics (8 of 13, 62 percent). No respondent reported a movement in attitude that was more negative than previously for each STEM discipline after participating in STEAM Girls enrichment activities.

Post-Focus Group

During a focus group led by four project leaders at the final STEAM Girls meeting, 7 (n=7) of 17 respondents discussed what they liked, what should be increased, and how they felt about the enrichment program. Project leaders took notes and reached consensus in their individual notetaking, including themes, after the activity. Five major themes emerged as follows.

1. Interested in STEAM Girls activities,
2. Liked activities that included pride in Native American culture,
3. Enjoyed SDSU engagement,
4. Reinforced positive feelings about STEM studies and careers, and
5. Hoped that activities could continue.

We did not further summarize statements within the themes because of the small sample and in order to avoid diluting Native voice. The following are quotations from respondents for each of the major themes.

Interesting Activities

- "They were different from anything I have ever done before."
- "I liked that each lesson was different each time."
- "I liked it when we spread those [traditional] seeds out."
- "I like it when we painted the dry milkweed pods as dried flowers."
- "I liked what we did today [planting traditional bushes and trees] a lot. It is something I have always wanted to do."
- "I plan on loving my job and not dreading it. When I am older, I want to do something I love doing."

Cultural pride

- "I would look at the plants that we used to eat back then and plant more of them."
- "Some of my favorite parts included the cooking, and making food was fun. It is more cool to make traditional foods, but it was fun just to learn to do stuff."
- "I liked cooking traditional foods, jelly and *wojapi* [a fruit pudding]."
- "It would be cool to learn about other cultures, like where other people came from. My best friend is Apache, and I did not know anything about how sacred pollen is for them."
- "The beadwork lessons were interesting. It is really cool to find out how other tribes do things."
- "We would rather plant the kinds of plants we grew up around. In my area, that would be chokecherry trees and plum trees. It is important."
- "We loved learning about what the SDSU students were learning about at the SDSU traditional [Native American] dinner."
- "It would be cool to have someone who teaches American Indian Studies to tell us more about what Native Americans used to plant and things like that – someone like Dr. [Gary] Larson from the Taylor Herbarium."
- "It would be cool to show student success stories from Native American students who majored in STEM."
- "I think it would be helpful to major in STEM, and then I could go and do STEAM Girl stuff like this to help explain these things to other people to help the profession."
- "My grandpa used to make the blueprints of our roads, and he shaped how they are now."
- "There are engineers right now trying to put a pipeline through my rez [reservation]."
- "Going to the American Indian Student Center helped because we learned from people who are experiencing campus life and have knowledge about it."
- "Grandmas know a lot, and they can teach you, if they want to."
- "This women's society idea would be really cool, especially hearing what the elders have to say. That would get a lot more girls involved, too. Having even more staff would be cool, too."

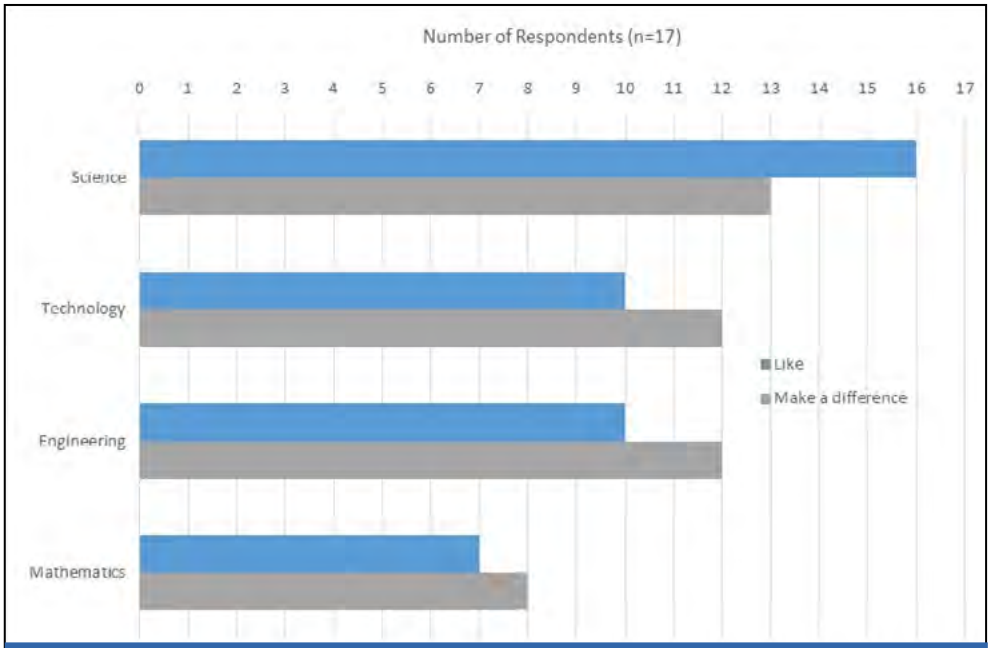

Figure 4. After participating in STEAM Girls activities, a majority of respondents answered "agree" or "strongly agree" that they like STE and that by majoring in those disciplines and obtaining a degree, they could help to improve their communities. The exception was mathematics.

Positive SDSU engagement

- "The ice cream manufacturing tour [at SDSU] was pretty cool. We had a walking tour there. We explored what they do, and they told us some of the students were creating their own flavors."
- "I liked going to SDSU and meeting all of the other students. You guys are cool."
- "We should have more SDSU students get involved. We had two or three students, but they could not always make it. It is still cool because we got to learn about their experiences."
- "I liked visiting the College of Nursing at SDSU and putting needles in fake arms as the activity there."
- "Bring more SDSU interns so we can hear more student stories."

Reinforcement of positive interest in STEM studies and careers

- "I liked it when we went to the field and learned more about the Daktronics scoreboard and engineering [at SDSU].
- "Those engineering lessons with Dr. Burckhard were really cool. I never knew that candy was made like that."
- "I live right next to a river, and it is going to make me think a lot about the plants and how we can learn more about them."
- "I was interested in STEM before, but these lessons reinforce my idea."
- "I really liked the STEM activities, and I was not thinking of STEM at all, before."
- "Taking a class for science now, this has helped reinforce the STEM stuff."
- "Back at home, all of our plants look different to me

now. Even our sage does not look the same."

- "I think [that majoring] in natural resources would be really cool."

Hope that activities can continue

- "I hope this will be here next year."
- "I was exposed to a lot of things in this program, but there was not enough time to learn it."
- "We should do more trips, like the one to EROS, and more exploration of other programs."
- "We should meet more often, twice a month, during our science classes."
- "We could do a field trip on a Saturday or Sunday."
- "I hope we can do more of this next year. Are you coming back then?"

Discussion

Overall, there is scant literature on culturally responsive teaching and learning enrichment activities to increase STEM interest among Native Americans, especially studies limited to girls. We found that such an approach with Native American high school students is worthwhile, in agreement with practices reported in North Dakota by Padmanabhan and others (2006).

The current study indicates that culturally responsive (Dakota/Lakota) STEAM activities generally increased interest in STEM studies and careers in this situation among high school girls at FIS, a Federal Native American boarding school, although STE were sometimes viewed more positively than mathematics. Such results confirm other reports of some Native American students' negative feelings about mathematics in the state (Kant, et al., 2015a; Sanovia, 2016, p. 70). Results showed that respondents' reported liking of individual STEM disciplines was positively related to their perceptions that engagement in those disciplines might help the respondents' home communities, confirmed in research by Kant and others (2015a) and in reports from Davis and others (2016).

Results indicated that women role models helped to increase STEM interest within this age group of girls. Such results are in alignment with Microsoft research (2017) that has recommended women role models and reaching this age group of girls as key to future STEM interest among older girls and women across Europe.

We found that tribally responsive, hands-on enrichment activities were important motivators, even among FIS girls whose tribes were at opposite ends of the United States; indigeneity mattered. While Hammond (2015) reported that culturally responsive teaching and learning does not have to include "racial background" in lesson content, our study found that including tribal traditions helps.

With the intention of increasing "cultural capital" and "social capital," based on insights from Bourdieu (1984) and Lareau (2011), one of the purposes of the bus trips for the STEAM Girls was to allow participants to ask questions about how "the system" works. The four bus trips were not meant to result in the participants' suddenly catching up with middle class students who had a head start, but, rather, to provide a glimpse into how the STEAM Girls could make the system work for them. The bus trips allowed STEAM Girls to see that others, with whom they might identify--for example, SDSU Native American student assistants--are successfully making the system work for them at SDSU. The bus trips helped the STEAM Girls to understand what it takes to go to college, and the credentials it takes to work as professionals conducting activities such as those that they observed at EROS. The STEAM Girls asked numerous questions of students from SDSU and tour guides throughout the trips, as they increased their "cultural and social capital" by gaining answers to their questions such as the following.

Where do I live on campus? How much does it cost? How do I get the money to pay for college? How much would I need to study? How long do students attend? What are the different types of degrees? Which classes do I take? How do I select a major? What kinds of jobs are available after college? Where would I live after college? How much money would I make after college? Could I get a job on a reservation after college since unemployment is high there?

Limitations of the Study

Partly because of legal and ethical restrictions in working with high school girls in a marginalized and vulnerable population of Native Americans at a Federal boarding school, there are at least five limitations of the study. First, project leaders originally intended to work with the same group of 32 interested girls as a cohort selected by FIS administrators, teachers, and counselors. Meeting with the same group was not possible. As a result, the PI and Co-PI's made modifications in the interests of technical action research which includes doing projects "*with*" rather than "*to*" participants (Cousin, 2009, p. 151) and in the interests of Native voice. There is so little research on culturally responsive STEAM teaching and learning among Native American high school girls, that project leaders gratefully accepted the FIS operational rules, including in-depth Federal background checks for project leaders and student assistants from SDSU. Furthermore, project leaders collected and analyzed data without full access to participants'/respondents' identifying data, such as tribal affiliations or states of origin because of privacy considerations at FIS.

Second, the original plan had been to include a pre-survey as a comparison group before the team conducted STEAM Girls enrichment activities, but that plan was abandoned for reasons that follow. A non-voluntary pre-survey had been administered to 36 FIS students by an FIS employee, and thus the PI and Co-PI's from SDSU eliminated the pre-surveys from the study as per SDSU's IRB (Institutional Review Board) protocol in keeping with their written statements distributed to proposed participants and to FIS administration that all project activities would be voluntary and without penalty of any kind.

Third, it is likely that the focus group of STEAM Girls respondents was too polite to be critical of the activities in such a face to face, non-anonymous setting. The STEAM Girls indicated often that they wanted Native American women students from SDSU to return to FIS and to continue the activities. The high school student participants were probably reluctant to be critical in surveys and the focus group to keep the project going. The STEAM Girls may not have been aware of technical distinctions between science, technology, engineering, or mathematics disciplines when providing responses, particularly when using the acronym "STEM."

Fourth, the team's activities favored science and engineering with less technology and mathematics, although leaders emphasized the interdependency of STEM throughout.

Fifth, since this is exploratory research, we do not claim its generalizability, although we recommend testing it at other places. The National Center for Educational Statistics (2008) cautions researchers about over-generalizing in studies concerning Native Americans with small samples and with self-identified racial or ethnic affiliations. This project's exploratory research involves complex relationships with many alternative variables that are not examined.

Conclusions and Recommendations

Because of the small size of the study population and non-randomization, results should be viewed with caution, particularly statistical statements in this exploratory research. Results indicated that culturally relevant STEM enrichment activities combined with Native arts and crafts, increased interest in STEM studies and careers for Native American high school girls in this situation at this place, although mathematics remains somewhat problematic. A majority of respondents reported that they agreed or mostly agreed that they liked STE studies and believed that through obtaining college degrees in those subjects, they might improve the quality of life in their home communities. The participation of women role models and hands-on learning also increased interest in STEM, especially when the role models were Native American college students. Themes that emerged from a post-project focus group included interest and cultural pride in the enrichment activities, enjoyment in interacting with SDSU, reinforcement of positive feelings about STEM studies and careers, and hope that the enrichment activities could continue.

Results showed that small steps in the journey to bring equitable representation in STEM to Native American girls may be through 1) first creating *interest* through tribally-related and culturally responsive enrichment activities including women role models; 2) generally increasing participants' cultural and social capital through visits to tribally relevant STEAM resources such as universities, herbaria, science centers, art centers, and museums; 3) including Native voice so that activities are done with Native Americans, not to them; and 4) providing consistent culturally responsive teaching and learning exposure, rather than one-time projects such as those in this study.

The long-standing problem of under-representation of Native Americans in STEM studies and careers requires more exploratory research aimed at discovery, to reach the point of testing in-depth hypotheses and forming in-depth research questions after the manner of Smith and others (2014). Each piece of the exploratory and discovery process, such as the current study, adds to a menu of successful practices in bringing STEM education to Native American girls at particular places. We further recommend that champions of STEAM integrate a culturally responsive teaching and learning approach into tribally-related schools in order to discover the impact on STEM interest, if any, in those places. We recommend future research into ways to improve interest and skills in mathematics in grades K-12 on and near reservations, in view of its centrality in the STEM complex.

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